Results of an Anaerobic Dechlorination Survey

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The anaerobic dechlorination review and principles and practices manual goals are to collect publicly-available information on the state-of-the-art in application of anaerobic dechlorination technologies, conduct a comparative analysis of the results, and produce a report detailing the state-of-the-art and provide guidance on how to promote effective applications. The project has been conducted in phases:

Site Survey Phase

This task involved completion of a literature review and site survey that focused on collecting available information on the state-of-the-art in application of anaerobic dechlorination technologies. The interim report summarized the information collected during the Phase I Site Survey. An expert working group was assembled to assist in preparing this report, providing an unbiased consensus of the results and conclusions.

A total of 93 sites were included in the Site Survey Phase.

- Of the 93 sites, 60 were industrial facilities, 30 were DoD facilities, and 3 were DoE facilities.
- The sites were distributed in 32 states across the continental US, with international sites in England, Japan, and the Netherlands.
- The most prevalent contaminants targeted for remediation were TCE and PCE. Chlorinated ethenes were the reported target compounds for enhanced anaerobic dechlorination, with one site targeting perchlorate as well.
- Of the 93 sites, lactate was applied at 14 sites, butyrate at 3 sites, acetate at 3 sites, molasses at 15 sites, fructose at 1 site, lactose at 1 site, methanol/acetate at 2 sites, ethanol at 1 site, sodium benzoate at 1 site, HRC™ at 35 sites, edible oils 10 at sites, mulch at 3 sites, chitin at 1 site, and hydrogen at 3 sites.
- Pilot-scale studies were reported for 59 sites, combination pilot-scale and full-scale studies were reported for 9 sites, and full-scale only studies were reported for 21 sites. The scale of application for 4 sites is currently unknown.
- The earliest reported pilot studies were initiated in 1995 for the Hanford 200 Area Site (January), the Emeryville Manufacturing Facility (August), and the Avco Lycoming Superfund Site (November). The Emeryville and Avco Lycoming sites both went to full-scale in 1997.
- Several sites (molasses and HRC™ applications) have been confirmed as closed, are approved for conditional closure, or have been approved for post-closure monitoring by the governing regulatory agency. ARCADIS (2002) reports three site closures: one with closure to concentrations below MCLs, one with no-further-action, and one conditional closure. Overall, Regenesis (Koenigsberg, 2002) reports 18 site closures: 12 sites closed to below MCLs, 1 site closed with no-further-action, and 5 sites with some form of conditional closure.
- The majority of sites are still under evaluation. This is likely due to the fact that the majority of applications have been implemented during the past 2 to 3 years, and the time-frame to determine the effectiveness of enhanced bioremediation is on the order of months to years.

Principles and Practices Phase

A second phase, which is ongoing, will review information regarding the electron donor sources and application approaches compiled in this Site Survey Phase. The Environmental Security Technology Certification Program (ESTCP), the Naval Facilities Engineering Service Center (NFESC), the Air Force Center for Environmental Excellence (AFCEE), and the Army Environmental Center (AEC) are cooperating to develop a guidance document for DoD restoration program managers (RPMs) and their contractors to use when considering enhanced bioremediation as a remedial alternative for chlorinated compounds in groundwater.

The currently outlined sections of the document include a summary of the state of the practice. This section will discuss common enhanced bioremediation applications for source area treatment, plume restoration, and plume containment, the microbiology of enhanced reductive dechlorination and electron donor addition alternatives.

Site and technology selection criteria will also have its own section in the document. Sections will include regulatory considerations, impacts to water and air quality, source area or dissolved plume size, and a discussion of appropriate hydrogeology, contaminant distribution, and groundwater geochemistry.

A more in depth discussion of microbial issues will be covered in the document. Sections on the geochemical requirements for reductive dechlorination, evaluating potential for enhanced anaerobic dechlorination, biodegradation screening, laboratory microcosms, and determining completeness and rates of degradation will be included in the document.

Mixing and delivery will have its own section in the principles and practices document. Sections will include a discussion on delivery, distribution of different electron donor types. Other issues covered include implementation constraints and biofouling control methodologies.

System Monitoring & Performance Validation will be the last section of the document and will highlight different monitoring strategies. In addition, tracer testing, data interpretation and monitoring and performance lessons learned will be included.

In addition, two case studies for each of the following substrates will be presented in the appendices:

- Substrates applied as a dissolved phase. Lactate and molasses are the most common substrates applied as a dissolved phase and will be included. .
- Slowly Soluble Substrates. Slowly-soluble substrates include HRC™ and edible (vegetable) oils. These substrates are intended as slow-release substrates where a single or limited number of injections are sufficient to remediate a site.
- Solid Phase Substrates. Solid phase substrates include mulch. Mulch is generally obtained from shredding and chipping of tree and shrub trimmings, and is actively composted prior to emplacement to provide active microbial populations for further degradation of the substrate in the subsurface.
- Gaseous Hydrogen. The role of H_2 as an electron donor is widely recognized in controlling the anaerobic dechlorination of CAHs.